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Optimization of drilling conditions of Glass fibre reinforced plastic composite material using genetic algorithm.

Dr. N.S.Mohan, Dr Jagannath K, Dr S.S.Sharma, Dr.Chandrashekar Bhat.

Manipal Institute of Technology, India

Abstract: Glass fiber reinforced plastics are finding increased applications in various engineering fields such as aerospace, automotive, electronics and other industries. Drilling is one of the most frequently practiced machining processes in industries owing to the need for component assembly in mechanical structures. In this work, the constrained optimization of cutting conditions is determined and treated by the application of genetic algorithm to determine the optimum values of cutting speed and feed rate which yield minimum cost of drilling operation performed on a TRIAC VMC CNC machine. The results indicated that the model can be effectively used for predicting the machining conditions yielding the minimum cost of operation and the results are compared with the optimization results obtained using geometric programming.

Keywords: Genetic algorithm, Glass fiber-reinforced thermoplastics, Thermoset plastics.

I. Introduction.

Composite materials are continuously replacing traditional materials due to their excellent properties. The use of light-weight materials means an increase in the fuel efficiency of automobiles and airplanes. In fact, drilling is one of the most common manufacturing processes used in order to install fasteners for assembly of laminates. Therefore, a precise machining needs to be performed to ensure the dimensional stability and interface quality Hence, the spindle speed, feed rate of the machining operation should be selected carefully in the machining of glass fiber composite materials. From the above literature, it is very clear that Productivity involves the higher, metal removal rate and Tool life result in the less rejection of the components. Therefore, it is necessary to understand the relationship among the various controllable parameters and to identify the important parameters that influence the quality of drilling. Moreover, it is necessary to optimize the cutting parameters to obtain an extended tool life and better productivity, which are influenced by cutting conditions.

2.0 Experimental work. High strength E-glass chopped fiber mat was used as reinforcement in polyester resin to prepare laminate slabs of 200mm x 200mm size. Above mat consisted of an E-glass with 72.5 Gpa modulus and density of 2590 kg/m^3. The resin polyester possessing a modulus of 3.25 GPa and density 1350 kg/m^3 was used in preparing the specimens with contact moulding process. Required numbers of mats were stacked to the required thickness and to a fiber volume fraction of 0.63.

2.2. Machining Set-Up. High strength E-glass chopped fiber mat was used as reinforcement in polyester resin to prepare laminate slabs of 200mm x 200mm size. Above mat consisted of an E-glass with 72.5 Gpa modulus and density of 2590 kg/m^3. The resin polyester possessing a modulus of 3.25 GPa and density 1350 kg/m^3 was used in preparing the specimens with contact moulding process

The Carbide-coated drills bits used in the experiments were of 3mm, 6 mm, 10mm and 12 mm diameter. Drilling tests were performed on a CNC TRIAC VMC machining center supplied by Denford, UK. The instrumentation consisted of a force- torque strain gauge drilling dynamometer, fixture, and an amplifier, connecting cables, an A/D converter for data acquisition as shown in the Fig.1.

Figure.1 Experimental Setup

3.0 Genetic Algorithm. The genetic algorithm (GA) method is a technique used to solve complex optimization problem.Genetic algorithms derive their name and basic features from nature and evolution, which can be considered as a steady process of optimization as well. In this work, genetic algorithm is used to optimize the machining parameters during the process of drilling through composite materials. The goal is to minimize the costs for this operation by determining the optimum values of cutting speed and feed rate, also considering a number of constraints, such as the maximum machine torque and the maximum axial force. The experiments have conducted and the resulting values are verified and qualified by using the genetic algorithm optimization method.

5.0 Results and discussion.

The solutions calculated by the MATLAB genetic algorithm toolbox are displayed in the command window after terminating the algorithm. Naturally, the outputs presented are varying from run to run ,because of the random nature of the algorithm. These discontinuities depend on the adjustments and rules defined for the GA, they however stay in a minor range compared to the result itself, which leads to one more or less definite solution.

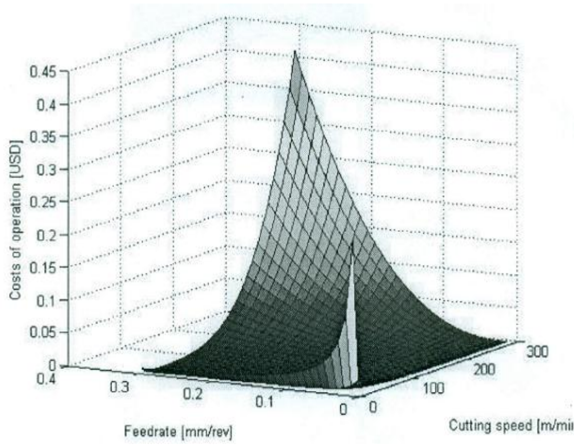

Figure 3. Plot of the objective function

For the cutting speed *V* there is only one constraint or bound so it can be handed directly to the GA. But as there are six constraints for the feed rate, they have to be evaluated and only the dominant one has to be given to the GA. This can be used to experiment with the results and to create a broader variety of solutions offered to the optimization problem.In order to be able to compare the computed results with the dominant constraints and also to provide a clear overview over the settings of the genetic algorithm toolbox, these features are displayed along with the results in command window. The graph of the objective function, figure 3 shows one extreme in the origin and also increases with growing values of the two axes representing the cutting speed and the feed rate. While the optimum value for the cutting speed is found around 175.3, the feed rate lies very mm close to its upper bound with an optimum value of 0.1395. The numeric value of the resulting costs for the operation with the optimized parameter settings is Rs. 1.495. A change in the settings of the MATLAB genetic algorithm toolbox like the number of generations or the function value change tolerance has virtually no effects on the results. Experimental verification of the optimized cost has been related in terms of machining time.

	Genetic Algorithm	Geometric Programming	Measured Results
Feed mm/rev	0.1395	0.15	0.14475
Cutting Speed in m/min	175.3	186.2	180.75
Cutting Time min	1.652	1.741	1.57

6. Conclusions.

Based on the experimental and genetic modeling results, the following conclusions are drawn:Genetic algorithm based model for machining conditions and cutting cost is developed from the experimental data. It's is very clear that the predicted output values and measured values are fairly close to each other, which indicate that the genetic algorithm model can be effectively used to predict the machining conditions and the cutting cost in drilling GFRP composites.The verification results with the results of geometric programming reveal that the both methods give fairly close results and hence genetic rule based model is suitable for predicting the machining conditions and the machining cost which is the function of machining time.Utilization of this tool can improve the productivity and quality of drilled part; if online monitoring is introduced. This tool can reduce the tedious model making, computational cost and time.

7. References.

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